INTELLIGENT LOCATOR SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention: The present invention relates generally to an electronic locating and annunciating system for a facility and, more particularly, to a system which can continuously operate to maintain a registry of the locations in the facility of individuals and equipment; and store and generate reports of a real time record of movement from location to location of individuals and equipment in the facility.

2. Description of the Prior Art: The need to maintain an up-to-date registry of the location of the personnel and equipment in a facility such as a building is oftentimes required to allow efficient operation. While the present invention is not so limited, an intelligent locator system is needed in a hospital setting, for example, to quickly locate operating personnel or emergency equipment at critical times. The ability to review accurate records of movement of personnel and equipment over time greatly enhances the ability of management to plan and maximize the utilization of resources, and allow a detailed study of events after an incident. One of the simplest methods for locating personnel within a facility involves a network of loudspeakers and phones or other response equipment. Such a network does not allow for locating equipment, only personnel. Also, broadcasting an announcement throughout the entire facility is distracting to all and requires an active response by the person being located. Furthermore, it is impractical with such

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network to maintain an up-to-date register for monitoring the location of personnel. U.S. Patent Nos. 3,436,320; 3,696,384; and 3,739,329 disclose utilizing ultrasonic transmitters and receivers; however, there are disadvantages because the use of

5 ultrasonics in these systems causes excess battery drain in the transmitters; and the ultrasonic signals pass through walls in a facility resulting in erroneous location indications.

Other prior art systems have been developed utilizing electro-magnetic wave energy in the infrared frequency spectrum

10 for the transmitters and receivers. For example, German Patent No. 32 10 002 discloses a system using infrared light emitters which transmit periodic signals for detection by a receiver that in turn energizes relays to register the presence of a person carrying the infrared emitters. No suggestion is made for

15 preventing signal overlap between two different periodic signals transmitted by emitters carried by two different individuals. Additionally, the infrared emitters operate continuously which degrades battery longevity.

Also disclosed in U.S. Patent No. 4,275,385 is a

20 personnel locating system which maintains a registry of individuals by tracking their entry and exit from defined areas. Each person carries a portable transmitter, and each transmitter transmits a unique twelve bit binary code word with start, stop and parity bits employing infrared light emitting diodes.

25 Infrared receivers are positioned to allow detection of the binary code word transmitted by the transmitter. However, the

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receiver can only detect the transmitted code word over a limited range, and only when the receiver is positioned so as to be in the "line of sight" of the transmitter. To overcome this problem, the receivers are positioned in doorways to rooms

5   forming the defined area. When a person carrying a transmitter passes through the doorway, such passage is detected. The system therefore actually tracks the entrance and exit of personnel from the rooms rather than continuously maintaining the locations of the personnel. As a result, this prior art system also suffers

10   from several inherent disadvantages. First, because a receiver only detects the transmitted signal during the brief period of time in which personnel pass through a doorway, any transmission problem occurring during this period of time results in the entry and/or exit of the personnel not be registered. Because a unique

15   multi-bit code word as well as parity and stop/start bits must be transmitted in sequence by a portable transmitter in order to correctly identify the personnel passing through the doorway, any bit error results in an incorrect registry entry. Additionally, the number of receivers required to maintain an accurate registry

20   of personnel increases greatly if a room contains more than one doorway allowing entrance and exit. A still further disadvantage inherent to this system occurs when two or more individuals enter through a doorway simultaneously in close proximity to one another (i.e., within the envelope of the receiver). The

25   receiver cannot differentiate between the transmitted signals. Again, an erroneous registry indication results as no individual

is registered as entering and/or exiting through the doorway.

Still further, an erroneous registry indication also results when

personnel pass within the envelope of the receiver, but do not

pass through the doorway. For example, in a hospital setting,

5   personnel walking along a hallway may pass within the envelope of

several receivers positioned in the doorways of several rooms,

but enter none of the rooms. The system would register such

personnel in all of the rooms at the same time. In a hospital

setting such false information is actually more detrimental than

10 no information at all.

SUMMARY OF THE PRESENT INVENTION

According to the present invention there is provided a

locating and monitoring system installable on the premises of a

facility, the system including at least one transmitter means

15 adapted for movement about the facility with a person, with an

animal or with equipment to allow identification of such

transmitter means at any of diverse sites in the facility, the

transmitter means including means for transmitting pulse bursts

at diverse times during predetermined time intervals for

20 preventing synchronization with resident signals in the facility,

the pulse bursts defining a unique binary identification code,

and means responsive to the pulse bursts for establishing the

location of the transmitter means in the facility.

Advantageously, a plurality of transmitters and a

25 plurality of receivers form part of the system. The receivers

each have a reception range about a premises with an allowable

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overlap with the reception range of another of such receivers.
Each of the receivers is responsive to the pulse bursts to
validate the binary identification code and thereby establish
presence of the transmitter means within the reception range of a
5   receiver. The receivers are joined to a gathering station for
validating outputs from each of the receivers and forming start
and stop events. The start events include the identity of the
one receiver of the plurality of receivers, the binary
identification code of one transmitter of the plurality of the
10   transmitters, and when the pulse bursts of such transmitter was
detected by such receiver. The stop events include the identity
of the one receiver of the plurality of the receivers, the unique
identification code of the one transmitter when loss of reception
has occurred within the reception range, and when such loss of
15   reception occurred. The receivers are connected to communicate
as a group with a plurality of the gathering stations connected
by a serial port to a central computer having a storage medium
for storing the start and stop events. In the preferred form of
the present invention, the system is issued for tracking the
20   movements of hospital personnel and allied hospital equipment,
and interfacing to an existing nurse call hospital system by
providing: that each of the plurality of the transmitter means
comprises a portable communication badge worn by allied hospital
personnel, including nurses, and attached to the hospital
25   equipment; the means for establishing the location including a
receiver installed in each patient room to interface with the

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nurse call hospital system; a receiver installed in each patient
room for indicating when the allied hospital personnel wearing
one of the badges is in the room, and the class of a number of
classes to which the allied hospital personnel belongs; and an
5   interface between the central computer and the nurse call
hospital system such that location queries entered at terminals
of the hospital system are routed to the central computer.

According to a further aspect of the present invention
there is provided a locating and monitoring system installable on
10   the premises of a facility, the system including at least one
portable transmitter means adapted for movement about the
facility with a person, with an animal or with equipment to allow
monitoring of such transmitter means at any of diverse sites in
the facility, the transmitter means including means for
15   generating infrared pulse bursts defining a unique binary
identification code essentially including an error detection
word.

In another aspect of the present invention, the system
includes at least one transmitter means adapted for movement
20   about the facility with a person, with an animal or with
equipment to allow identification of such transmitter means at
any of diverse sites in the facility, the transmitter means
including infrared means for generating pulse bursts defining a
unique binary identification code according to a pulse position
25   scheme wherein at least two binary bits of the code are
represented by one pulse.

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In a still further aspect of the system of the present invention includes at least one transmitter means adapted for movement about the facility with a person, with an animal or with equipment to allow identification of such transmitter means at

5 any of diverse sites in the facility, the transmitter means including means for transmitting pulse bursts defining a unique binary identification code, and a plurality of receiver means responsive to the pulse bursts for establishing the location of the transmitter means in the facility, and a gathering station

10 joined to each receiver of the plurality of receivers for validating outputs from each of the plurality of receivers and forming start and stop events, the start events including the identity of the one receiver of the plurality of receivers, the binary identification code of the transmitter, and when the pulse

15 bursts of such transmitter was first detected by such receiver; the stop event including the identity of the one receiver of the plurality of the receivers, the unique identification code of the transmitter when loss of reception has occurred within the reception range, and when such loss of reception occurred.

20 BRIEF DESCRIPTION OF THE DRAWINGS

Still other objections and advantages of the present invention will become apparent when the following description is read in light of the accompanying drawings in which:

Figure 1 is a block diagram of the intelligent locator

25 system according to one embodiment of the present invention;

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Figure 2 is a block diagram of the intelligent locator system in a hospital nurse-call system according to a preferred embodiment of the present invention.

Figure 3 is a timing diagram showing three simultaneous infrared identification code transmissions;

Figure 4 is one example of timing diagram of bits comprising an identification code burst;

Figure 5 is a timing diagram showing details of a pulse position scheme according to the present invention;

Figure 6 is a schematic illustration of the circuitry of the intelligent locator transmitter forming part of the systems of Figures 1 and 2;

Figure 7 is a block diagram of the intelligent locator receiver forming part of the systems of Figures 1 and 2;

Figure 8 is a schematic illustration of the circuitry for the infrared preamplifier for the intelligent locator receiver shown in Figure 7;

Figure 9 is a schematic illustration of the circuitry for the intelligent locator receiver forming part of the systems of Figures 1 and 2;

Figure 10 is a block diagram of the intelligent locator arbitrator forming part of the systems of Figures 1 and 2;

Figure 11 is a schematic illustration of the circuitry forming part of the intelligent locator arbitrator forming part of the systems of Figures 1 and 2;

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Figure 12 is a block diagram illustrating the intelligent locator computer forming part of the system of Figures 1 and 2; and

Figure 13 is a schematic illustration similar to Figure 6 and of a modified form of the circuitry of the intelligent location transmitter that can be used in the systems of Figure 1 and 2.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring first now to the block diagram of Figure 1, there is illustrated one form of intelligent locator system according to the present invention which is useful as a stand alone system for tracking and locating persons and equipment in a hospital; tracking and locating persons and/or product and equipment in a factory, warehouse, retail store or other space; keep records of progress of new product through the production process in a factory, and tracking animals in a storage and feeding facility.

The intelligent locator system of Figure 1 includes a central control computer such as a Personal Computer having a 386 central processor identified for the purpose of disclosure of the present invention as an intelligent locator computer 2 because of interfacing with allied components of the system. A serial data bus 4 supplies commands between a serial port of the computer 2 at least one and up to preferably 32 local gathering stations identified as intelligent locator arbitrators 6_1, 6_2 - - - 6_{32}.

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The computer 2 may also include additional serial ports coupled to data bus lines 4_1, 4_2 - - - 4_n of a plurality of such intelligent locator arbitrators 6_1, 6_2 - - - 6_{32}.   Communication over serial data bus lines 4_1, 4_2 - - - 4_n is based on, but not

5   restricted to the Electronic Industries Association standard RS-485.   Each arbitrator 6_1, 6_2 - - - 6_{32} communicates by a serial data bus 8_1, 8_2 - - - 8_{32}, with up to 32 intelligent locator receivers 16_1, 16_2 - - - 16_{32}.

The intelligent locator arbitrators 6_1, 6_2 - - - 6_{32}

10   each includes a +15 DC volt power supply 14 to supply electrical power to the associated arbitrator and line 10 to supply electrical power to intelligent locator receivers 16_1, 16_2 - - - 16_{32} coupled to the associated intelligent locator arbitrator. A ground line 12 is arranged parallel with line 10 which forms an

15   electrical ground potential common to all of arbitrators and receivers. All the intelligent locator receivers associated with the various intelligent locator arbitrators are responsive to anyone of at least one but preferably a plurality of intelligent locator transmitter badges 18_1, 18_2, 18_3, 18_4 - - - 18_n, each of

20   which, as will be described in greater detail hereinafter, transmits an unique bit code when chosen with 20 bits to enable up to 1,048,576 badges uniquely recognizable by the system. More than 20 code bits can be used to allow more than 1,048,876 badges to be uniquely recognized by the system. A bit code greater than

25   20 bits may be adopted with out departing from the spirit of the present invention.

The intelligent locator badges 18 are constructed in a
manner suitable to be worn by persons, animals, and/or equipment
and transmit a unique identification code using infrared
transmissions. The receivers 16 with infrared detectors are

5   installed at any of various different locations throughout a
facility to allow detection of the unique code emitted by any of
intelligent locator transmitters 18 within a detection range.
While the invention is not so limited, these receivers 16 can be
installed in walls, floors, ceilings, structural parts, and

10   special mountings provided in the facility. The functions of
intelligent locator arbitrators 6_1, 6_2 - - - 6_{32} is to process the
signals to determine when an unique identification code emitted
by the intelligent locator transmitter 18 starts being detected
by any intelligent locator receivers 16_1, 16_2 - - - 16_{32} and when

15   the code stops being detected. The arbitrators transmit signals
corresponding to these start and stop events to the computer 2.
A maximum of preferably 32 intelligent locator arbitrators 6 may
be connected to a serial port of the intelligent locator computer
2 via the RS-485 serial bus 4. This gives rise to the

20   possibility of up to 1024 intelligent locator receivers 16 per
intelligent locator computer 2 serial port. The operating
software of the intelligent locator computer operates to read
into the computer memory the start and stop events from the
intelligent locator arbitrator's 6, time stamps the events, and

25   stores the data of the event in a relational database.

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A system user will be able to input a request to the intelligent locator computer 2 terminal and/or generate a report of the present location of any person, animal, or equipment which is wearing an intelligent locator transmitter badge 18 including

5   movement of the badge with the person, animal, or equipment over any previous time period.

Referring now to the block diagram of Figure 2, there is illustrated, in block form the preferred embodiment of the intelligent locator system for use in a specific application of a

10   computer controlled hospital nurse call system, preferably a Wescom System 3000 (TM). The nurse call system includes a nurse call CPU 26 having an input device 26A such as a key board. The CPU 26 fulfills the function of a central computer controlling the nurse call system that also includes one or more nurse-call

15   central control terminals 22_1, 22_2, - - - 22_{32} each connected to communicate over a standard RS-232 bus 24 with the nurse call CPU 26. Terminals 22_1, 22_2, - - - 22_{32} are each connected by a parallel data bus 28 to communicate with patient room stations 32 dispersed about a local area of the facility such as a floor of a

20   hospital. The nurse call CPU 26 is coupled by an ethernet high speed serial data bus 20 using standard tcp/ip protocol with the intelligent locator computer 2. When operating with a nurse-call system, the intelligent locator system of the present invention replaces automatic or manual locators that are normally found

25   with such a system. When nurses wearing the intelligent locator transmitter badges enter a patient's room in response to a call,

the intelligent locator system automatically detects their presence and communicates that information to the nurse-call system and thereby eliminates the need for the nurses to manually register their presence. An example of the operation of the

5   system shown in Figure 2 is that the intelligent locator computer 2 stores information identifying the level of the person or personnel wearing all badges, e.g., RN, LPN, aid, as well as the specific identity of the nurse wearing that badge and transmits the level information back through the intelligent locator

10   arbitrators 6_1, 6_2 - - - 6_n and through intelligent locator receiver 16_1, 16_2 - - - 16_{32} to the patient stations 32 which need that level information to determine whether the nurse being detected by the intelligent locator receiver 16 is of the requisite qualification level to respond to the need of the nurse

15   call placed at the patient station.

The nurse-call system operators, at their own nurse-call terminals through the ethernet communication line 20 between the intelligent locator computer cpu 2 and the nurse-call cpu can request information about the current location of any nurse,

20   other personnel or hospital equipment wearing an intelligent locator transmitter badge 18. A detailed description of the construction and operation of intelligent locator arbitrator 6, intelligent locator receiver 16 and intelligent locator transmitters 18 follows.

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An important feature of the present invention is the coding for transmission and decoding of received pulse bursts at diverse times during predetermined time intervals to define an unique binary identification code for the operation of the

5   locating and monitoring system. To facilitate an understanding of the underlying principle of the present invention, reference is now made to the diagram of Figure 3 wherein there is illustrated timing diagrams in graphical form of three simultaneous infrared transmissions by three separate intelligent

10   locator transmitters over a four second period. It is an important and novel feature of the present invention that a pulse burst of 20 milliseconds duration defines a unique binary identification code that is transmitted approximately once a second with its position in time relative to the start of each

15   second determined by an algorithm. As shown in Figure 3, for illustrative purposes only, when the code bursts 40 of all three badges happen to line up at the same time of 0 second thus interfere with one another as depicted at the far left of Figure 3, then during the next second all three pulses and any two of

20   the pulses will not simultaneously occur or line up in time because the pulses emitted by their respective transmitters occur in time according to a different code determined by when the pulse transmission occurred during the preceding second. In this way, multiple badges carried into the same room of a facility can

25   be distinguished from one another by their infrared pulse transmissions as detected by the receiver. Moreover, the

infrared transmission by only one such transmitter can be uniquely identified from all other infrared pulse transmissions whether from other badge transmitters or sources of infrared pulse transmissions occurring within the facility. In this

5   regard it is to be noted that infrared pulse transmissions may be emitted by equipment or devices carried by persons within the facility. Thus, the present invention is intended to enable unique identification of any given badge with respect to other

10   badges and sources of infrared transmissions. The algorithm for determining when within each second the unique identification code is transmitted by a infrared pulse burst resides in the software of a microcontroller forming part of the intelligent locator transmitter 18. The algorithm functions by accessing

15   through a 20 bit identification code at a rate of 1 bit per second using a current bit value of "0" or "1" to determine whether to transmit a code burst during the first half or the second half of the current second. The algorithm also functions at the same time to step through the 20 bit identification code

20   at a rate of 4 bits at a time during each second and using a current 4 bit part of the code to determine when the pulse bursts are to be transmitted within that first or second half of a second. The time span of a second was chosen arbitrarily and may, for example, comprise a time period 1 and 1/2 seconds long.

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As described in regard to Figure 3, the pulse bursts occur for a duration of time selected for the purpose of describing the present invention to be 20 milliseconds. In Figure 4 a 20 millisecond time interval is depicted during which 14 infrared pulses, each identified by reference numeral 42, occur with an approximate 10 microsecond duration which is identified by reference numeral 44. The 20 millisecond burst transmission is made up of 3 components. The first is a start bit interval 46 during which an initial pulse 42 occurs to synchronize the receiver 16 for reading the transmission. The second component of the pulse transmission are 10 pulses occurring during an interval 48 representing a 20 bit code. A third component of the pulse transmission, which also comprises an important novel feature of the present invention, are three pulses 42 representing a 6 bit checksum occurring during an interval 50 and detected and used by a receiver 16 to insure integrity of the received data.

Referring again to the time interval 48 of Figure 4, this interval is depicted with greater detail in Figure 5 wherein the graphical illustration represents a timing diagram of the pulse position scheme used to represent 2 binary data bits by the transmission of 1 infrared pulse transmission 42. It is a further important novel feature of the present invention to provide that each infrared pulse 42 represents 2 binary bits of code which not only reduces the number of necessary infrared pulses to define the code but also offers a material saving to

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the life of a battery power supply for the transmitter. It is of
vital importance to conserve battery power consumed by the
operation of the transmitter. Battery drain occurs when the
infrared emitters are turned ON for each pulse. This is a

5   significant advance over known prior art systems which used a
burst of pulses for each bit with the pulse occurrence being
varied in frequency to distinguish "0" from a "1". In Figure 5
each 10 microsecond duration 44 represents the emission of an
infrared pulse 42 that occurs sometime during a 1.5 millisecond

10   bit space 52. The bit space is defined to provide 4 discrete
time intervals within which a pulse can occur. When a pulse
occurs during the first of the 4 intervals, it represents a 2
binary bit code "00" which is shown to occur during the bit space
60 as a third code pulse. When a pulse occurs during a second of

15   the 4 intervals, it represents a 2 binary bit code "01" which is
shown to occur during the bit space 56 as a first code pulse.
When a pulse occurs during a third of the 4 intervals, it
represents a 2 binary bit code "10" which is shown to occur
during the bit space 62 as a fourth code pulse. When a pulse

20   occurs during a fourth of the 4 intervals, it represents a 2
binary bit code "11" which is shown to occur during the bit space
58 as a second code pulse.

         As noted above, only 4 intervals of a defined 6
interval bit space are used for the occurrence of a pulse. The

25   first interval occurring before the middle 4 intervals and the
sixth interval occurring after the middle 4 intervals enable the

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circuity of the receiver 16 to distinguish between successively

occurring pulses especially where, for example a second code

pulse "58" defines a code "11" is followed by a third code pulse

60 defining a code "00".

5   INTELLIGENT LOCATOR TRANSMITTER 18

In Figure 6 schematically illustrated is the circuitry

of an intelligent locator transmitter useful in the systems of

Figures 1 and 2. The transmitter 18 includes a microcontroller

70 comprised of an IC package containing a programmable memory

10   for an operating program whose function is to define an unique 20

bit identification code for identifying the transmitter uniquely

among all other transmitters and other sources of possible

infrared pulse emissions occurring within the receiving range of

the receivers 16. A microcontroller suitable for use in the

15   preferred embodiment of the present invention is a Microchip

PIC16C54LP, which is a low voltage CMOS device. The

microcontroller operates at a slow speed set externally at, for

example, 32 kilohertz, by a quartz crystal 72 which is the

minimum speed sufficient to generate identification code pulses

20   and minimize power consumption which is directly related to the

speed of operation. A serial bit stream of 125 microseconds wide

logic pulses is output on data line 74 to a monostable multi-

vibrator 80 formed by an IC package per se well known in the art

to produce an output on line 81 in the form of 10 microsecond

25   pulses for transmission which turns ON a MOSFET transistor 82.

Infrared light emitting diodes 84A and 84B are energized when

transistor 82 is turned ON.   Diodes 84A and 84B, per se well

known in the art, are preferably selected to emit bursts of

infrared radiation at a wave length preferably selected at 940

nanometers.   Resistor 76 and capacitor 78 forms an RC circuit

5   which determines the 10 microsecond pulse width output by multi-

vibrator 80.   Coin-sized flat lithium cell batteries 90A, 90B,

90C and 90D supply power for the operation of the intelligent

locator 18.

Diodes 86 and 88 are arranged to form rectifiers by

10   their connection between 90A, 90B, 90C and 90D for protecting the

circuitry of the transmitter in the event the batteries are

installed with their polarity reversed.   The transmitter can be

turned OFF by operation of switch 92 coupled in power supply line

93.   Capacitor 94 stores an electrical charge between pulse

15   emissions which is discharged when the light emitting diodes 84A

and 84B are turned ON for emitting high intensity emission

pulses.   A serial arrangement of diodes 96, 98 and 100 establish

a low voltage in line 68 for powering the microcontroller 70.

The voltage setting function of diodes 96, 98 and 100 contributes

20   to a reduction of power consumption by reducing the operating

voltage supplied to the microcontroller 70.   Capacitor 102

coupled between the voltage supply line 68 and ground minimizes

noise and other interference to insure reliable operation of the

microcontroller 70 by forming a buffer and filter in the voltage

25   supply line 68.

INTELLIGENT LOCATOR RECEIVER 16

      In Figures 7, 8 and 9 schematically illustrated is the circuitry of an intelligent locator receiver which is useful in the embodiments of the systems shown in Figures 1 and 2. Turning

5   first to Figure 7, there is illustrated by the block diagram two circuit boards, one of which is a preamp board 106, and the other a logic board 108 which are mounted to a single gang face plate for installation in a wall or in a ceiling of a room within the premises of a facility where the system of the present invention

10   operates. Preamp board 106 is mounted directly to the face plate and logic board 108 forms the back board mounted behind the preamp board in a piggy-back fashion. Preamp board 106 includes Pin photodiode 118 for detecting by impingement infrared pulses 104 emitted by an intelligent locator transmitter 18. Three

15   light emitting diodes 120, 122 and 124 emit different colors of light to give a visual indication on the receiver face plate of three possible levels of persons such as nurses, e.g. RN, LPN and aid whose presence is detected by the system. The logic board supplies power to the preamp board for the operation thereof

20   including illumination of the light emitting diodes 120, 122 and 124 in response to signals received in a three wire bus line 116 from the logic board. The logic board decodes pulses output from the preamp board in line 110 to validate a code and communicate a validation of the code by data transmission to intelligent

25   locator arbitrator 6. It will be understood that the system of Figure 2 provides that the arbitrator 6 forwards data to the

receiver 16 that includes information in the form of a signal indicative of the level of the nurse detected by the intelligent locator receiver which has been recorded thereby.

Figure 8 shows the greater details of the preamp board
5   106 wherein it can be seen that there is included an infrared preamplifier 126 having input terminals coupled to PIN photodiode 118 and an input terminal coupled to receive a +12 VDC power supply by line 112. A common ground potential is also presented by line 114. Infrared pulses impinging on diode 118 cause a
10   forward biasing thereof causing a pulse input of current to the preamplifier 126 which converts the current pulse whose duration is 10 microsecond to a 12 volt logic pulse of approximately 50 to 300 microseconds in duration. The pulse width is directly proportionate to the intensity of the detected infrared light
15   pulse and is communicated to the logic board by line 110. The diode 120 designed to emit green light is coupled through a current limiting resistor 128 to indicate by designation a nurse level presence of "1" by the occurrence of a low voltage level in line 116A received from the logic board 108. The diode 122
20   designed to emit yellow light is coupled through a current limiting resistor 130 to indicate by designation a nurse level presence of "2" by the occurrence of a low voltage level in line 116B received from the logic board 108. The diode 124 designed to emit red light is coupled through a current limiting resistor
25   132 to indicate by designation a nurse level presence of "3" by

the occurrence of a low voltage level by line 116C supplied by the logic board 108.

Figure 9 shows greater details of the logic board 108 wherein the circuitry includes a voltage protection diode 134 in the +15 VDC input 10 and a filter capacitor 136 that is parallel with a 12 voltage regulator 138 whose output is a 12 VDC power supply filtered by capacitor 140 for delivery to preamp board 106 by line 112. The preamp board 106 is coupled to ground potential by ground line 114. The +12 VDC output from voltage regulator 138 is also coupled to form an input to a voltage regulator 142 whose output is a +5 VDC filtered by capacitor 144 for powering 5 volt logic devices on the logic board that include microcontroller 158, a universal asynchronous receiver transmitter hereinafter identified as uart 156, and a RS-485 serial data transceiver 148. The +12 VDC logic pulses occurring as outputs from preamplifier 126 in line 110 are input to a voltage level conversion circuit that includes voltage level resistors 162 and 164, the latter coupled to the gate of transistor 168 which outputs through resistor 166 +5 VDC pulses to the microcontroller 158. The microcontroller 158 samples the input bursts to establish the validity of an identification code. The validation is made when the identification code consists of, as shown in Figure 4, a start pulse 46 followed by 10 pulses 48 representing a 20 bit code, followed by three pulses 50 representing a 6 bit checksum.

For this purpose, the microcontroller 158 includes an operating program to perform an important and believed novel feature of the present invention of causing operation of the microcontroller to recalculate a checksum by using bursts from

5   the received identification code and then comparing the freshly calculated checksum with the checksum received with the identification code. When the freshly calculated checksum equals the checksum received with the identification code, the code is established as valid. When the comparison shows an inequality of

10 the compared checksums then the code bursts pulses transmission is ignored. In this way, if too few code burst pulses or too many code burst pulses (as in the case of overlapping pulse transmissions) are detected then those transmissions are also ignored.

15   When the operation of microcontroller 158 establishes the validity of a received identification code then the microcontroller outputs a signal corresponding to the validated code to the intelligent locator arbitrator 6_1, 6_2 – – – 6_{32} by way of the RS-485 serial data bus 8. An operating clock for the

20 microcontroller 158 is formed by a quartz crystal 160. In the system shown in Figure 2, the arbitrators 6_1, 6_2 – – – 6_{32} return the nurse level information corresponding to that received identification code to the microcontroller 158 of the receiver. This nurse level information is then transmitted to the patient

25 station 32 by the three lines 30A, 30B and 30C which incorporate protection diodes 150, 152 and 154. The microcontroller 158

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outputs signals through base resistors 170, 174 and 178 coupled
through transistors 172, 176 and 180 respectively, to lines 116A,
116B and 116C to energize the respective light emitting diodes
located on the intelligent locator receiver preamp board 106.

5   The microcontroller 158 also communicates with arbitrator 6 by
the RS-485 databus 8. As can be seen from Figure 9,
microcontroller 158 responsive to an operating clock formed by
quartz crystal 160 communicates through the uart 156 and the RS-
485 interface integrated circuit 148 with arbitrator 6 over data

10   lines 8A, 8B, 8C and 8D collectively forming data bus 8. The
uart 156 is an integrated circuit whose function is to convert
parallel data received from microcontroller 158 to serial data
and output the serial data at a selected baud rate to the RS-485
interface integrated circuit 148. The uart 156 also receives

15   serial data at a selected baud rate from the integrated circuit
148 and performs a conversion to parallel data which is read as
an input to microcontroller 158. The uart 156 derives its
operating clock from a quartz crystal 146.   The RS-485 interface
IC 148 delivers serial data output by the uart 156 to

20   differential outputs 8A and 8B to be transmitted over a twisted
wire pair. Also, the RS-485 interface IC 148 converts
differential inputs in lines 8C and 8D from a twisted pair line
to serial data inputs which can be read by the uart 156.

<u>INTELLIGENT LOCATOR ARBITRATOR 6</u>

25   In Figure 10 schematically illustrated is a block
diagram of the circuitry of the intelligent locator arbitrator 6

useful in the systems of Figures 1 and 2.   The arbitrator

includes a logic circuit board 182 and a +15 VDC power supply 14.

Power supply 14, per se well known in the art, chosen from any

one of a variety of commercially available units to deliver about

5   3 amps at 15 volts DC through a rectifier circuit coupled by line

184 to a standard 115 VAC line.   Power supply 14 outputs +15 VDC

in line 10 having a branch line 186 coupled to the logic board

182.   Similarly, line 12 at ground potential also emerging from

the power supply has a branch line 188 coupled to establish

10   ground potential for the logic board 182.

Referring now to Figure 11, the details of the

circuitry forming the intelligent locator arbitrator circuit

board 182 is illustrated wherein it can be seen that the +15 VDC

input 186 is protected by diode 198 followed by a grounded filter

15   capacitor 200.   Beyond the capacitor 200 in the circuit is a

regulator 202 whose output is at a potential of +5 VDC filtered

by grounded capacitor 204 for supplying power to all of the

devices that include microcontroller 222, universal asynchronous

receiver transmitters 214 and 216, hereinafter referred to as

20   uart 214 and 216, RS-485 serial data transceivers 206 and 208,

signal control latches 218 and 220, the static rams 190 and 194

and the ram address latches 192 and 196.

As shown the microcontroller 222 communicates with the

intelligent locator computer 2 by the RS-485 serial data bus 4

25   through uart 214 and the RS-485 interface integrated circuit 206.

Additionally, the microcontroller 222 communicates with the

intelligent locator receiver 16 by the RS-485 type serial data

bus 8 through uart 216 and the RS-485 interface integrated

circuit 208. The uarts 214 and 216 take the form of integrated

circuits which receive parallel data from the microcontroller

5   222, convert the parallel data to serial data and output the

serial data at a selected baud rate to the RS-485 interface

integrated circuits 206 and 208. The uarts 214 and 216 also

receive serial data at a selected baud rate from the RS-485

interface integrated circuits 206 and 208 and convert the serial

10   data to parallel data read in by the microcontroller 222. Quartz

crystals 210 and 212 form operating clocks for the uarts 214 and

216, respectively. The RS-485 interface integrated circuits 206

and 208 convert serial data outputs from the uarts 214 and 216,

respectively, to differential outputs in lines 4A and 4B

15   extending to the intelligent locator computer 2 with respect to

IC 206 and lines 8A and 8B extending to the intelligent locator

receivers 16 for transmission by way of twisted pair wire. The

RS-485 interface integrated circuit 206 converts differential

inputs received from twisted pair wires 4C and 4D from the

20   intelligent locator computer to serial data inputs read by uart

214. The RS-485 interface integrated circuit 208 converts

differential inputs received from twisted pair wires 8C and 8D

from the intelligent locator receivers 16 to serial data inputs

read by uart 216. The microcontroller 222 latches all its

25   external control signals to the other integrated circuits on the

intelligent locator arbitrators logic board 182 in two 8 bit

latch integrated circuits 218 and 220. This enables the microcontroller 222 to expand its 8 bit data output port to drive 16 control signals. The microcontroller 222 also latches the address bus of the static rams 190 and 194 in two 8 bit latch

5   integrated circuits 192 and 196. This enable the micro-controller to multiplex its 8 bit data bus with the 15 bit address bus of the static rams 190 and 194. Quartz crystal 224 forms an operating clock for the microcontroller 222.

Each arbitrator 6 is connected by an RS-485 serial bus

10   8 to process signals from a maximum of preferably 32 intelligent locator receivers 16. Each arbitrator 6 operates to establish the event when a transmitter 18 is first detected by a receiver 16 and the event when a transmitter 18 is no longer detected by a receiver 16 and transmits such start and stop events as signals

15   to the intelligent locator computer 2. The microcontroller 222 in each arbitrator 6 through operation of a resident program reads the identification codes reported by each intelligent locator receiver 16 by way of RS-485 serial bus 8. If an identification code transmitter 18 has been carried into the

20   detection range of a receiver 16, the microcontroller 222 sends a start event message containing the identification code and an identification number of that receiver 16 to the computer 2 by the RS-485 bus 4. The microcontroller 222 also stores that identification code in a static ram 190 and 194 in a table of

25   information for that particular receiver 16. As long as the receiver 16 continues to report that identification code, the

identification code remains in the static ram 190 and 194.

However, when the intelligent locator stops a reporting of the

identification code for more than 10 seconds, the microcontroller

222 sends a stop event message to the computer 2 and removes that

5   identification code from the static ram 190 and 194 for that

intelligent locator receiver 16.   In the particular

embodiment of the system shown in Figure 2, the microcontroller

222 also receives and stores in ram 190 and 194 a table of nurse

level information from the intelligent locator computer 2.

10   The table of nurse level information includes a list of

identification codes of the badges worn by nurses and the nurse

level of each such person e.g., RN, LPN or aid.   When an

intelligent locator receiver 16 reports an identification code

which corresponds to one of the nurse codes, the microcontroller

15   222 sends that nurse level information to that intelligent

locator receiver 16 by the associated RS-485 serial bus 8.   In

this way, the receiver 16 is supplied with a signal to turn ON

one of the nurse level light emitting diodes 120, 122 or 124 and

at the same time to deliver a signal to the patient station 32

20   indicating the presence of a nurse and to which of the three

levels the nurse belongs.

<u>INTELLIGENT LOCATOR COMPUTER</u>

In Figure 12 schematically illustrated is a block

diagram of the intelligent locator computer 2 useful in the

25   systems of Figures 1 and 2.   The computer 2 contains an intel 386

personal computer central processing unit 228, a monitor 226 for

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viewing data, a keyboard 232 for entering the data, an RS-232 to

RS-485 converter box 240, a terminal for the ethernet bus 20 and

a printer 242 coupled by an interface to the CPU 228. The CPU

228 also includes its own power supply which includes a line 230

5   for receiving 115 VAC. The PC CPU 228 controls the monitor 226

through an interface cable 234. An interface cable 238

interfaces the keyboard 232 with the CPU 228. The converter box

240 is used to convert standard RS-232 data from a serial port

236 of the CPU to the RS-485 data bus 4. Operating software in

10   the CPU 228 receives start and stop events from the arbitrators

6, time stamps these events and stores the events in a data base.

The start event includes an identifying number of the intelligent

locator receiver 16, the identification code of the transmitter

18 within the range of the receiver 16 and the real time of the

15   occurrence of the start event.

The stop event includes the identifying number of the

receiver 16, the identification code of the transmitter 18

removed from the reception area of the receiver 16 and the real

time of the occurrence of the stop event. The computer 2 has a

20   front end interface to enable an operator to request the location

of that person or object wearing a transmitter 18. In the

embodiment of Figure 2, CPU 228 has an ethernet interface for

interfacing with the nurse call CPU 26. The ethernet interface

can also be used to attach a terminal server to allow the

25   capability of multiple terminals for use throughout the facility

where operators can request location information about any

transmitter 18. The CPU is equipped with necessary means

including software for generating reports detailing previous

movement of any transmitter over a period of time which can be

generated and viewed at the terminal or reduced to hard copy by

5   the printer 242.

In Figure 13 schematically illustrated is another

embodiment of the transmitter 18 wherein like reference numerals

identify the same parts identified and described hereinbefore in

regard to Figure 6. In Figure 13, a four position logic switch

10   69 is included which is connected to inputs 71 and 73 of

microcontroller 70 and sets a two bit code on inputs 71 and 73 of

microcontroller 70. The operating program of the microcontroller

70 reads this two bit code on its inputs 71 and 73, and

incorporates that two bit code in its 20-bit identification code

15   for transmission. This additional two bit code forms data, which

is changeable in the field via the switch 69, is useful in the

system of Figure 2 to differentiate the three levels of nurse

(RN, LPN, aid) from other identification badges. In this

embodiment, the receivers 16 determine nurse level information

20   directly from the received pulse bursts and pass that information

to the patient station 32 without have to wait for the arbitrator

6 to look up that level information in a table and communicate

that information back to the receiver 16.

While the present invention has been described in

25   connection with the preferred embodiments of the various figures,

it is to be understood that other similar embodiments may be used

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or modifications and additions may be made to the described

embodiment for performing the same function of the present

invention without deviating therefrom. Therefore, the present

invention should not be limited to any single embodiment, but

5   rather construed in breadth and scope in accordance with the

recitation of the appended claims.

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